

Manitoba
Environment



WESTERN AND NORTHERN CANADA ACID DEPOSITION LRTAP ACTIVITIES

ANNUAL REPORT 1988

A report on monitoring and research
studies related to acid rain and long-range
transport of atmospheric pollutants
in Western and Northern Canada



Province of British Columbia

Alberta



Saskatchewan
Environment and
Public Safety



Environment
Canada
Environnement
Canada

ANNUAL REPORT 1988

**A report on monitoring and research
studies related to acid rain and long-range
transport of atmospheric pollutants
in Western and Northern Canada**

**Prepared by the
Technical Committee for the
Long-Range Transport of Atmospheric
Pollutants in Western and Northern Canada**

August 1989



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MAP OF WESTERN CANADA



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1. INTRODUCTION

HISTORY

The Governments of British Columbia, Alberta, Saskatchewan, Manitoba and Canada have recognized the potential for harm from acid deposition in some parts of western Canada. A commitment was made in Edmonton on September 4, 1980 by the deputy ministers of the four western provinces and senior officials from Environment Canada to cooperate on issues related to the Long Range Transport of Air Pollutants (LRTAP). A Consultative Committee of deputy ministers and a Technical Committee of senior officials were established at that time to coordinate monitoring, research, and other activities. In 1982, the Government of the Northwest Territories joined these committees and a three year program was launched to identify current conditions in western and northern Canada and to provide information for developing management strategies. In March 1984, a second three year agreement was signed in recognition of the continued cooperative efforts towards a better understanding of the LRTAP issue in western and northern Canada. In 1988, a third three year agreement ending March 1991, was signed to reaffirm the commitment of the mentioned governments towards coordinated research and monitoring activities related to LRTAP.

Current Status

Currently soils and geology and surface water sensitivity maps for western and northern Canada have been prepared. A framework for developing interim target loadings based on literature from around the world was suggested. Monitoring continued at the provin-

cial and federal levels, emission inventories were kept and mathematical models to describe the phenomenon of transport, transformation and deposition of airborne pollutants in the medium range (10 to 500 Km) were addressed.

Future Activities

The major research thrusts up to March 1991 are listed below. These are identified in detail in the document signed in April 1988*.

1. Determination of the sensitivity of western and northern Canadian environment to acidic deposition.
2. Establishment of scientifically validated target loadings to protect highly and moderately sensitive aquatic and soil systems in western and northern Canada.
3. Continuation of monitoring activities with particular attention to:
 - a. sulphate and nitrate deposition rate in precipitation;
 - b. characterization of total deposition (wet versus dry);
 - c. quality of sensitive surface waters and terrestrial environments especially where data gaps exist;
 - d. characterization of the role of nitrate, ammonia, and metals deposition in the western and northern Canadian environment.
4. Validation of mathematical models to assist in management strategies.

A summary of the monitoring and research activities related to acid deposition and LRTAP carried out in western and northern Canada during 1988 follows.

*Western and Northern Canada Long Range
Transport of Atmospheric Pollutants-Ob-
jectives and Three Year Program: 1988-
1991, by Western and Northern Canada
LRTAP Technical Committee, April, 1988.

2. BRITISH COLUMBIA

2.1 EMISSIONS AND CONTROL TECHNOLOGY

Sulphur Emissions in a Coastal Area

The data presented in the report on sources of sulphur emissions on Vancouver Island and in the Southcoastal area of the Province mentioned in the Annual Report 1987 have now been analyzed. Based on this analysis, a draft in-house report was prepared jointly with the Ministry of Energy, Mines and Petroleum Resources. The report discussed the potential reduction in sulphur emissions if the existing pulp and paper mills power boilers and recovery boilers burning high-sulphur oil were switched to either low-sulphur oil or natural gas.

Report: A report is available from the Waste Management Branch, Ministry of Environment, British Columbia.

Inventory of Emissions

Joint work involving the Ministry of Environment and Environment Canada is complete. A description of this work is in Section 8.

Report: See Section 8,

Inventory of Emissions in Greater Vancouver

The Greater Vancouver Regional District, in collaboration with Environment Canada and the British Columbia Ministry of Environment has completed an inventory of the emissions of sulphur oxides, nitrogen oxides, particulates, carbon monoxide, and volatile organic compounds. The inventory (which began

in 1985) includes all sources - mobile sources, point sources, and area sources - in the Lower Mainland.

Report: See Section 8.

2.2 AIR QUALITY AND DEPOSITION

Precipitation Chemistry Stations

The province of British Columbia continued weekly monitoring of precipitation with automatic collectors at Cranbrook, Kamloops, Kelowna, Kitimat, NanOOSE, Port Hardy, Pender Island, Seymour Dam, Smithers, Spectacle Lake, Squamish, Vancouver (airport), and Victoria. A new station in the Greater Vancouver Regional District (East Richmond) was added.

These monitoring stations provide weekly data on the rate of sulphate deposition, from which the annual rate of sulphate deposition is calculated. The values for 1987, expressed in kilograms per hectare per year (kg/ha/y) are: Cranbrook 4.3, Kamloops 1.2, Kelowna 1.5, Kitimat 16.9, NanOOSE 7.1, Port Hardy 14.4, Smithers 1.7, Squamish 26.1, Spectacle Lake 5.9, Vancouver 12.8 and Victoria 16.8 (estimated).

Annual rates of sulphate deposition for 1987 at Seymour Dam and East Richmond are not available.

Report: The annual acid precipitation monitoring reports for 1984, 1985, 1986 and 1987 are available from the Waste Management Branch, Ministry of Environment, British Columbia.

2.3 SURFACE WATERS

pH Tolerance of Aquatic Plants of British Columbia

The study of the pH tolerance of aquatic plants of British Columbia is being conducted in three parts. Part 1 was a literature review of the pH limits of aquatic plants of the world. Part 2 involved analysis of existing environmental data relative to the presence of species of aquatic plants in British Columbia. Part 3 will involve experimental work to determine pH limits for some common aquatic plants for British Columbia.

Report: Reports on Part 1 and 2 data are available from the Water Management Branch, Ministry of Environment, British Columbia.

Lake Trend Monitoring

Monitoring is being conducted to determine whether acidic inputs are causing a significant deterioration of water quality. Water samples are collected monthly at six sensitive lakes in the south-western part of the province: Vancouver Island, Saltspring Island and Lower Mainland. Analysis of these samples includes pH, alkalinity, acidity, general ions and metals.

Also, phytoplankton and zooplankton are collected monthly from May through October. The planktonic organisms are identified, and chlorophyll-a is measured. On the basis of this measurement, estimates of algal biomass are made.

Maps of the distribution of aquatic plants (aquatic macrophytes) are made on the basis of surveys taken every five years. The program began in 1984 and data are to be analyzed in 1989.

Report: Data are available from the Water Management Branch, Ministry of Environment, British Columbia.

Water Quality Criteria

Water quality criteria have been developed for aluminum and are being developed for pH. These criteria place greatest emphasis on valued attributes of the British Columbia environment.

Report: Reports will be available in the future from the Water Management Branch, Ministry of Environment, British Columbia.

Lake Sensitivity Mapping

Lake sensitivity maps for British Columbia have been prepared.

Report: Maps are available from the Water Management Branch, Ministry of Environment, British Columbia.

2.4 SOILS AND GEOLOGY

Soil and Geology Sensitivity Mapping for British Columbia

Two maps have been prepared but are held in abeyance for publication. These are: Soil Sensitivity to Acidic Inputs; and Potential of Soils and Geology to Reduce Acidity of Atmospheric Deposition. Legends on the maps characterize mapping units for properties significant to the interpretation of sensitivity. Relative reliability of mapping is indicated. Mapping methods and sensitivity rating criteria used are based on those outlined by the Coordinating Committee on Soil and Geology Sensitivity Mapping. An accompanying report will describe methods, data sources and observations on sensitivity ratings.

Report: Further information is available from the Waste Management Branch, Ministry of Environment, British Columbia.

2.5 VEGETATION

Impact of Atmospheric Pollutants on Vegetation

The Ministry monitors the health of vegetation in various parts of the province where plants are exposed to sulphur, fluoride and heavy metals, and in conjunction with the University of Victoria, is developing techniques to determine the sensitivity to sulphur dioxide of alpine lichens found in northern British Columbia to sulphur dioxide.

The Province, in conjunction with the University of British Columbia, is conducting research on the damage to agricultural crops caused by various airborne pollutants including ozone at various concentrations and various durations.

The Ministry has an ongoing program to review the scientific world literature on atmospheric pollutants. This review covers a wide range of scientific activity, including research on primary pollutants (sulphur oxides, nitrous oxides) and secondary pollutants (ozone, heavy metals and organic compounds).

Compilation of environmental base data is continued for Prince George, Jarvis Creek-

Markhill River area and Vancouver Island and reports are being prepared.

At the international level, the Ministry is involved with the Western Conifers Cooperative of the Environmental Protection Agency (USA) and the British Columbia Ministry of Forests. These agencies are working in collaboration to estimate the impact of atmospheric pollutants on vegetation in the Puget Sound basin. A pilot study (in northern Vancouver Island) will use remote sensing techniques to measure damage to tree growth caused by sulphur dioxide. Methods developed in this pilot study will be used in the Puget Sound area.

Another international activity involving the Ministry of Environment, the Ministry of Forests, the University of Washington and the Simon Fraser University is a cooperative study on the effects of air pollution on seedling trees used in reforestation programs north and south of the international boundary.

Report: All of the projects described above are recent initiatives. Reports will be published, as the projects are completed.

2.6 HEALTH

There were no activities in this area in 1988.

3. ALBERTA

3.1 EMISSIONS AND CONTROL TECHNOLOGY

Sources and Emissions Inventories

There were no activities in this area during 1988.

3.2 AIR QUALITY AND DEPOSITION

Developments in Passive Monitoring of Ambient Sulphur Dioxide

A passive sampler was developed to monitor SO_2 in remote locations. The sampler has the same physical dimensions as Huey plates, which are currently used by Alberta Environment. This will allow them to be substituted in existing sample holders. Advantages of the new device, which consists of K_2CO_3 /Glycerol absorbent and a diffusion barrier, are linearity to ambient concentrations over a wide range of meteorological conditions and non-interference from H_2S . Ambient samples can be analyzed by Ion Chromatography (Dionex 2020i; AS4A column; continuous suppression) without interference. The sample is useful in that, it will enable lower levels of SO_2 such as those encountered in baseline sites to be determined more accurately.

A paper on the sampler was presented at the CPANS meeting held in Calgary on May 15-17, 1988.

Report: The paper is available from the Air Analysis and Research Branch, Chemistry Division, of the Alberta Environmental Centre, Vegreville.

Measurement of Dry Deposition

Attempts have been made to extend the use of the K_2CO_3 passive sampler to measure the concentration of SO_2 accurately as dry deposition. A similar passive sampler using triethanol amine (TEA) have also been tried to measure the concentration of NO_2 . These measured concentrations of SO_2 and NO_2 have been used in determining the dry deposition from the known "deposition velocities" for SO_2 and NO_2 .

Report: Results will be available from the Air Analysis and Research Branch, Chemistry Division, Alberta Environmental Centre, Vegreville.

Analysis of Precipitation Chemistry Measurements in Alberta

Alberta Environment commenced monitoring precipitation on a monthly basis in 1978 with six stations. Currently the network consists of thirteen stations. As well, daily precipitation samples are collected at one site. The chemical composition is monitored to detect significant changes resulting from industrialization within the province and provide an historical data base. Alberta precipitation has an average pH of 5.5, little different from the theoretical background value of 5.6. The calcium cation and sulphate anion are the most dominant species in precipitation, and more so in southern Alberta than in the northern part of the province. The highest hydrogen ion concentrations occur in the summer months, while the concentrations of most ions have their largest values in winter.

The average wet sulphate deposition in Alberta is approximately 10 kilograms sulphate per hectare per year; lower than the eastern

Canada target loading of 20 kilograms sulphate per hectare per year. In Alberta, unlike eastern Canada, the wet sulphate is not a direct measure of acid deposition because a large fraction of sulphate is not associated with the hydrogen ion. Corrections for sulphate associated with calcium and the relative importance of dry to wet deposition must be considered when comparing to a target loading.

Report: For further information, contact the Environmental Quality Monitoring Branch, Environmental Assessment Division, Alberta Environment.

Alberta's Position on Acceptable Acid Loading

The sulphate-based acid loading, as utilized in eastern Canada, cannot be used in Alberta because of the influence of alkaline dust. Accordingly, Alberta Environment has engaged HydroQual Consultants to prepare a report for the Department to set out its position.

*The terms of reference of this project
are as follows:*

To prepare a report for Alberta Environment summarizing the following information:

1. The general nature of predictive models developed in eastern North America and northern Europe to assess acidification potential and acidification status in lake and soil ecosystems (i.e., sulphate-based relationships).
2. The chemical characteristics of precipitation falling over Alberta, and the implications for sulphate-based modelling.
3. The rationale for the use of the

"effective acidity" approach in modelling acidification impacts, a description of methods for quantifying this variable, and estimates of present deposition in Alberta.

4. A description of predictive models which have been (or could be) used to assess the impact of acidic deposition in Alberta using the "effective acidity" approach.
5. An integration of the pertinent results of acidic deposition modelling carried out to date for soils and lakes in Alberta by the Alberta Research Council and by Alberta Environment.
6. Any further enhancement of the predictive analyses recommended by the consultant which would substantiate Alberta's position with respect to the measurement and assessment of acidic deposition in this province.

Report: For further information, contact the Standard Research and Development Branch, Environmental Assessment Division, Alberta Environment.

3.3 SURFACE WATERS

Lake Monitoring Network

The objective of this project is to establish long-term data bases which can be used to identify changes in either the trophic state or acidification status of a lake. Long-term monitoring has been initiated in four lakes in central Alberta (Wabamun, Nakamun, Baptiste, Ethel) which have been sampled at

monthly intervals since 1983. Two poorly buffered, unnamed lakes on the Muskeg Mountain Upland have been sampled monthly since May 1988.

Report: Data are available from the Environmental Quality Monitoring Branch, Environmental Assessment Division, Alberta Environment.

Lake Survey Program

This survey was designed to upgrade the lake water quality data base in areas of the province identified as containing lakes sensitive to acidic deposition. The water quality data base in the northern upland regions of the province is small and represents an amalgamation of historical data from various sources. A survey program on 47 lakes was initiated in northern Alberta (Birch Mountain Uplands, Muskeg Mountain Uplands, and Athabasca Plains) to validate and upgrade these historical data.

Report: Data are available from the Environmental Quality Monitoring Branch, Environmental Assessment Division, Alberta Environment.

3.4 SOILS AND GEOLOGY

Long-Term Measurement of the Acidification of Non-Cultivated Soils in Alberta

Eight monitoring sites have been established to measure the acidification of soils over a long period of time in areas where deposition of industrial acid precursors is expected to occur. The monitoring sites are intended to measure the worst situations, hence they will act as soil acidification early warning sites.

Two sites have been sampled each autumn since 1981. All sites will be resampled once every four years.

Report: A brief synopsis of procedures is available from the Soil Protection Branch, Wastes & Chemicals Division, Alberta Environment.

3.5 VEGETATION

No research or monitoring related to vegetation were undertaken.

3.6 HEALTH

Health Effects of Sulphur Gases

Research on the health effects of sulphur gases, particularly hydrogen sulphide, is ongoing. A major experimental study of the effects of exposure to 0, 1, 10, or 100 ppm hydrogen sulphide for 8 h/d, 5 d/w, for 5 weeks has been completed and the tissues and data are being analyzed. An investigation is in progress to determine the leakage sites for the massive pulmonary oedema seen after exposure to lethal or near-lethal concentrations of hydrogen sulphide. A collaborative study is nearing completion on the role of neurotransmitters in lung injury due to hydrogen sulphide. Future investigations include study of the effects on reproduction and productivity.

Report: For further information on this research, contact the Animal Sciences Wing of the Alberta Environmental Centre, Vegreville, Alberta.

4. SASKATCHEWAN

4.1 EMISSIONS AND CONTROL TECHNOLOGY

Saskatchewan Air Emissions Inventory of Sulphur Dioxide and Nitrogen Oxides

The inventory of sulphur dioxide and nitrogen oxides emissions is being updated for 1987. The inventory will be prepared according to the methods outlined in the emissions inventory methods manual developed by the Western Canada LRTAP Inventory Technical Working Group.

Report: A final report will be available next year from the Air and Land Protection Branch, Saskatchewan Environment and Public Safety.

4.2 AIR QUALITY AND DEPOSITION

Poplar River Thermal Power Plant Ambient Air Monitoring Program

Saskatchewan Environment monitors sulphur dioxide and suspended particulates at one location, Coronach. Few detectable concentrations have been recorded at this site. The highest hourly SO₂ concentration recorded in 1988 was 0.082 ppm, well below the provincial standard. The 24 hour average suspended particulates concentrations were within the provincial standards.

Report: Data summaries are available from the Air and Land Protection Branch, Saskatchewan Environment and Public Safety.

4.3 SURFACE WATERS

Surface Water Sampling in Northern Saskatchewan

Approximately 60 surface water stations in northern Saskatchewan are monitored. Most of the samples are collected by industry at the request of Saskatchewan Environment and Public Safety.

Report: Data summaries are available from the Mines Pollution Control Branch, Saskatchewan Environment and Public Safety.

4.4 SOILS AND GEOLOGY

No specific monitoring activities or studies were conducted with respect to soils and geology in 1988.

4.5 VEGETATION

No specific monitoring activities or studies were conducted with respect to vegetation response to acidic deposition in 1988.

4.6 HEALTH

No specific monitoring activities or studies were conducted with respect to health effect from acidic deposition in 1988.

5. MANITOBA

5.1 EMISSIONS AND CONTROL TECHNOLOGY

Emission Inventory

The inventories for nitrogen dioxide and sulphur dioxide are being maintained by the province.

Report: Data summaries and/or reports are available from Manitoba Environment.

5.2 AIR QUALITY AND DEPOSITION

Air Quality Monitoring in Northern Manitoba

No monitoring activities were conducted during 1988, with the exception of a station established in Flin Flon in December.

Report: Data summaries and/or reports for previous years of monitoring activities are available from Manitoba Environment.

Precipitation Monitoring

There was no precipitation monitoring on a daily basis in 1988.

Report: Data summaries and/or reports for previous years of monitoring activities are available from Manitoba Environment.

Snowpack Survey

Snow pack monitoring was carried out in March 1988 to determine wet and dry deposition of selected ionic species over the four

month wintertime period. The survey included 38 stations throughout the province. Samples were analyzed for pH, conductance, acidity, sulphate, nitrate, chloride, calcium, ammonium, magnesium, sodium and potassium. The pH readings were below 5.6 (the theoretical pH of uncontaminated precipitation) at 11 of 15 locations in the province. Except for Wekusko and Island Lake, the pH of snow at northern sites was generally below 5.0, ranging from 4.71 to 4.99. Wet and dry deposition of sulphate was generally lower than in previous years, ranging from 0.30 kg/ha to .58 kg/ha at sites with pH readings less than 5.0. If wet and dry deposition during the rest of the year occurred at the same rate, the annual wet/dry deposition of sulphate would range from 0.90 to 1.74 kg/ha, well below the maximum objective of 20 kg/ha adopted by Canada. Nitrate deposition to snow was slightly higher than in previous years especially at those sites with pH lower than 5.0. The range was 0.09 to 0.17 kg/ha (4 month accumulation) compared with less than 0.10 kg/ha in previous years. This increase probably balanced off the decrease in sulphate resulting in similar acidic inputs in previous years. Deposition of calcium to the snow was lower in 1988. Since calcium buffers the pH, this could be a reason why lower pH readings in the snowpack were experienced in 1988.

Windblown soil in southern Manitoba resulted in increased deposition of sulphate, nitrate and calcium relative to northern sites. The pH at southern sites were in the 5.4 to 6.4 range, with 3 of 5 sites greater than 6.0.

Report: Data summaries and/or reports are available through Manitoba Environment.

5.3 SURFACE WATERS

Surface Water Sampling

No specific water quality sampling related to LRTAP was carried out during 1988. A report on historic aquatic data related to LRTAP was produced during 1988.

Report: Reports and data summaries are available through Manitoba Environment.

5.4 SOILS AND GEOLOGY

No activities were carried out during 1988.

Report: A report on Manitoba Terrestrial Sensitivity to Acidic Inputs is available through the Manitoba Environment.

5.5 VEGETATION

Vegetation Studies Around Northern Smelters

Studies of coniferous regeneration response to heavy metal contaminated soil in the vicinity of mining and smelting complexes at Thompson and Flin Flon continue. A report on effects determined near the Inco smelter in Thompson has been released and work continues in the Flin Flon area. These greenhouse studies have shown that metal contaminated soils are inhibiting root growth of 24 week old seedlings of Black Spruce and Jack Pine. Of concern is a decline in natural regeneration of forests within 5 km of mining smelters.

Report: Reports are available from Manitoba Environment.

Tree Generation Study Near Thompson

Field plantings of Black Spruce and Jack Pine at Thompson are continuing with plans to

initiate similar plantations at Flin Flon. These studies are a follow up of greenhouse studies and are to determine effects of heavy metal contaminated soil on seedlings. Growth and development of root and shoot growth are being evaluated.

Report: The study is ongoing. Interim results are available from Manitoba Environment.

Terrestrial Monitoring

Eight forest monitoring sites are being routinely monitored in areas sensitive to acidic deposition throughout the province. This program is being carried out in cooperation with the Canadian Forestry Service's ARNEWS program.

Report: Baseline data have been collected and data summaries are available from Manitoba Environment.

5.6 HEALTH

Cadmium in Wildlife

Cadmium levels in kidney and liver of moose, deer, elk, wolf, coyote and bear have been monitored since 1987. This program is in response to concerns for potential mobilization of cadmium from soils as a result of acidic deposition. However, cadmium concentrations in Manitoba appear to be related to natural sources. The Manitoba Department of Health has issued recommendations to hunters that kidney of wildlife not be consumed and liver consumption be limited. Monitoring continues. This program is a cooperative study between the Manitoba Environment Department, the Manitoba Natural Resources Department and the Wildlife Toxicology Fund of Environment Canada.

Report: A report is available from Manitoba Environment.

6. NORTHWEST TERRITORIES

6.1 EMISSIONS AND CONTROL TECHNOLOGY

No activities

6.2 AIR QUALITY AND DEPOSITION

Aerosol Deposition

The Northwest Territories is supporting a study of aerosol deposition in snow cores, lake bottom sediment, and glacial ice in the central arctic. The study is being undertaken by Mr. Dennis Gregor, of the Inland Waters Directorate, Regina, Saskatchewan.

Report: Further information is available from the Inland Waters Directorate, Regina, Saskatchewan.

Precipitation Chemistry

A CAPMoN station was installed at Snare Rapids, about 150 km north of Yellowknife.

6.3 SURFACE WATERS

The Northwest Territories is supporting a study undertaken by the Inland Waters Directorate to measure hydrocarbons and other contaminants from long-range deposition in the Mackenzie Basin.

Report: For further information contact Brian Olding, Inland Waters Directorate, Yellowknife.

6.4 SOIL AND GEOLOGY

No activities.

6.5 VEGETATION

No activities.

6.6 HEALTH

Polar Bear Study

The Northwest Territories Wildlife Service and the Canadian Wildlife Service continued to take tissue samples from polar bears to measure the concentrations of polychlorinated biphenyls (PCB) and other organochlorides.

Report: Further information is available from the Wildlife Service Department of Renewable Resources (Yellowknife) and the Canadian Wildlife Service (Edmonton).

Blood Samples - Native Population

The study of polychlorinated biphenyls (PCB) concentrations in the native people of Broughton Island continued. This study, conducted by the federal department of Health and Welfare, Indian and Northern Affairs, and Fisheries and Oceans, is based on the analysis of PCB concentrations in breast milk and blood, and in the diet of the people.

Report: Further information is available from Health and Welfare Canada (Ottawa).

Also note that AES had undertaken studies on arctic haze at Alert, N.W.T.

7. FEDERAL GOVERNMENT

7.1 EMISSIONS AND CONTROL TECHNOLOGY

Inventory of Point Sources and Emissions in British Columbia

A contract study was completed for an inventory of point source emissions (year 1985) for the common air contaminants: polycyclic aromatic compounds, lead, cadmium, and vanadium. These data were combined with the mobile and area source inventories prepared by Conservation and Protection, and the emissions inventory prepared for the Greater Vancouver Regional district, to provide a comprehensive emissions inventory for the province.

Report: Report and information is available from: Pacific and Yukon Region, Environmental Protection, Conservation and Protection Service, Environment Canada, West Vancouver, British Columbia.

7.2 AIR QUALITY AND DEPOSITION

Hydrometeorology of the CANSAP Sampler

To determine the evaporative loss and undercatch of the CANSAP sampler, CANSAP and CAPMoN samplers have been installed at the Regina Airport. Samples were weighed daily, and a comparison of the sample weights was made. Sampling was completed in 1987, and focused solely on evaporative losses. Preliminary results indicate significant daily evaporative losses from the CANSAP sampler, but greatly reduced evaporative losses have been achieved with the improved design of the CAPMoN sampler. A final report on the project is expected to be completed in 1989.

Report: Information is available from: Atmospheric Environment Services, Regina, Saskatchewan.

British Columbia Transboundary Precipitation Chemistry

An analysis of event precipitation chemistry data gathered in southern British Columbia has been completed. Studies have also been conducted by agencies in Washington State to assess the local effects of the shutdown of the ASARCO smelter in Tacoma, Washington. A study has been proposed to link the local analysis with the more distant impacts to attempt an overall assessment of the ASARCO smelter closure. If approved, a report will be prepared by March 1990.

Report: Information is available from: Pacific Region, Atmospheric Service Vancouver, British Columbia.

Canadian Air and Precipitation Monitoring Network (CAPMoN)

CAPMoN is the national network for air and precipitation monitoring, with stringent siting criteria and sampling protocols such that each station is considered representative of rural and remote locations in Canada. Precipitation samplers used by this network open only during precipitation events. Daily precipitation samples are analyzed for: pH, sulphate, nitrate, chloride, ammonium, potassium, sodium, magnesium, and calcium. Air samplers sample on a daily basis using filter packs. Samples are analyzed for particulate, sulphate, nitrate, ammonium, potassium, sodium, gaseous nitric acid, and sulphur dioxide.

The western Canada portion of this network operating in 1988 consisted of the following:

Manitoba

McCreary
Island Lake

Saskatchewan

Cree Lake

Alberta

Ester

Northwest Territories

Snare Rapids (opened in October 1988)

British Columbia

Delays were encountered with the establishment of a station on Saturna Island. It is now expected to start operation during the summer of 1989.

Report: Data summaries of precipitation chemistry are published annually, and are available from: The Atmospheric Environment Services, Downsview, Ontario.

Western Canada Deposition Modelling (Statistical LRTAP Models)

Three LRTAP statistical models have been implemented and tested over the Prairies and British Columbia. Further sensitivity analyses are planned to investigate the effects of using various input parameters on deposition parameters. A report detailing this work and the implementation will be prepared by March 1990.

Report: Information is available from: Pacific Region, Atmospheric Environment Services, Vancouver, British Columbia.

7.3 SURFACE WATERS

Water Chemistry Sampling

Environment Canada monitors a large number of surface water sites in the Prairie Provinces and Northwest Territories on a monthly basis, or (primarily in the NWT) on a time-of-visit basis. This monitoring is conducted as part of the Water Quality Branch program, or as a result of agreements with the provincial governments or agencies. Periods of record average ten or more years, and are useful for assessing LRTAP effects.

Report: Information is available from: Inland Waters/Lands, Environment Canada, both in Regina, Saskatchewan and Yellowknife, Northwest Territories.

Water Quality Study of Elk Island National Park

Inland Waters/Lands and Canadian Parks Service have cooperated on a water quality study of Elk Island National Park. This study attempted, among other things, to assess the relative impact on the Park's aquatic environment of industrial activities nearby. Intensive sampling to detect the deposition of acidic, organic or other related contaminants, has been undertaken. Sampling included lake water, bottom sediments, biota, groundwater and snow. The study is finished, and a report was published in 1988 by a consultant.

Report: The report and information is available from: Inland Waters/Lands, Environment Canada, Regina, Saskatchewan.

Contamination of the Arctic Snowpack

Inland Waters Directorate commenced research

in 1986 into the presence of organic contaminants in the snowpack in the mid to high Arctic. This research was funded jointly by Environment Canada, Indian and Northern Affairs Canada and the Government of the Northwest Territories, and has provided preliminary evidence that contaminants are being deposited to the snowpack. Surveys in the Arctic during 1986, 1987 and 1988 have revealed detectable concentrations of PCB's, Lindane, alpha-BHC, heptachlor, chlordane, dieldrin, and a DDT metabolite p,p-DDE. Snowpack samples collected from Agassiz Ice Cap and Ellesmere Island show that the flux of many contaminants during the last 20 years is annually variable, but contaminants are always present.

Report: Information is available from:
Inland Waters Directorate,
Conservation and Protection,
Environment Canada, Regina,
Saskatchewan.

History and Current Fluxes of Atmospheric Pollutants to Remote Lakes in the Temperate Boreal and Arctic Regions of Canada

In collaboration with other DFO and DOE laboratories, Freshwater Institute staff have begun a research program to determine the history of deposition and current rates of supply of atmospheric pollutants to small, remote lakes in a north-south transect from Western Ontario to the high Arctic. We also are trying to determine the relation between these rates of supply of atmospheric pollutants and selected pollutant-stress enzyme systems in fish in these same lakes. We are also testing hypotheses concerning the possible concentration of volatile organic and metal pollutants in the Arctic, via the "cold finger effect", and the possibility that some of these atmospheric pollutants in high Arctic lakes are from air masses derived from the USSR, northern Asia,

and northern Europe.

We have designed, constructed and field tested a new sediment sampling tool, called a box corer, to obtain large samples of sediment. We can slice thin layers of lake sediment for the measurement of PCB, DDT, PAH, and many other organic pollutants, and lead, mercury and cadmium. These sediment layers can be dated, using the radioactive decay of natural Pb-210, in order to describe the history of deposition of these pollutants. Pb-210 measurements also calculate the flux, or rate of supply ($\mu\text{g}/\text{m}^2\cdot\text{yr}$) of each pollutant at the sediment surface.

We hope to relate this pollutant rate of supply to the activity of enzyme systems that are known to respond to pollutant stresses. Mixed function oxidase enzyme activity is thought to increase in response to exposure to certain organic pollutants, and this increased enzyme activity probably decreases fish growth and reproduction.

We are currently analyzing box cores from the Experimental Lakes Area (ELA) in Western Ontario, and Saqvaqujac (SAQ) on the West Coast of Hudson Bay. Cores will be obtained from Cornwallis Island lakes in June 1989. Atmospheric pollutant fluxes to ELA lake sediments are similar or slightly lower than in nearby Lake Superior. Deposition of PAH's (derived from coal and oil combustion) began at ELA around 1900, and peaked in the late 1950s and early 1960s. DDT, PCB and other organochlorine pollutants appear in the ELA sediments around the late 1940s, and increase to the surface sediments. The variability of lake trout MFO enzyme system activity is currently being studied. Similar measurements on the Arctic lake sediment cores at SAQ reveal that pollutant supply rates are much lower, and they appear in the sediments at a much more recent time.

The results of this work are intended to be related to similar measurement in other parts of Canada, USA, Europe, and perhaps some of the under-developed countries, where many of the organic pollutants have their origin.

Report: Information may be obtained from:
Fisheries and Habitat Management
Freshwater Institute,
Winnipeg, Manitoba.

*Biological Exposure Indicators for Metals
Discharged by a Smelter*

Eight lakes, four in Manitoba and four in Saskatchewan, were selected to evaluate effects on fish, crayfish, and zooplankton of atmospheric deposition of metals discharged by the smelter in Flin Flon, Manitoba. Lakes in Manitoba ranged from 10 to 31 km away from the smelter, and in Saskatchewan, lakes were from 6 to 26 km away from the stack. Lakes ranged from 40 to 677 hectares in surface area, and from 3.0 to 24.4 metres in maximum depth. Water chemistry parameters demonstrate wind-distance and wind-direction dependencies in sulphate deposition. These lakes, however, are not acidified (pH values range from 7.4 to 8.3). Four sediment cores, obtained by SCUBA diving were removed from the deepest portion of each lake. Cores were sectioned and analyzed for cadmium, copper and zinc. Metal profiles for these sectioned cores will be presented to quantify metal deposition since the beginning of smelter operations in 1930. Analyses of blood from two fish species, northern pike and white sucker, for concentrations of cells and electrolytes (sodium, potassium, calcium, glucose, and osmolality) indicate that osmoregulatory failure is not being produced by these metal loadings. Preliminary analyses of liver from these fish indicate that low-molecular-weight metal-binding proteins (metallothioneins) are increased in metal-exposed fish. These pro-

teins are correlated with increased tolerance to metal toxicity, and may serve to protect these fish from adverse effects produced by the metals. Several radiotracer displacement methods for rapid analyses of these proteins were evaluated and modified for use on aquatic biota. Using the modified method, metallothioneins were analyzed in fish liver and kidney, crayfish hepatopancreas, and whole zooplankton to determine their sensitivity and applicability as biological indicators of metal exposure. Results from these studies were presented at four national or international conferences during 1988. Three manuscripts are in preparation and will be submitted for publication prior to the end of 1989. This work was funded equally by LRTAP and the World Wildlife Foundation.

Report: Reports and information are available from: Freshwater
Institute, Fisheries, Winnipeg,
Manitoba.

*Experimental Lakes Area (ELA),
Northwest Ontario*

In Lake 223, experimentally acidified since 1976, direct toxicity effects of hydrogen and food chain effects on the biota have been observed at relatively high pH values (5.5-6.0) and many species were lost from the food chain. During 1988, a partial recovery phase was continued for the fifth consecutive year, with the mean epilimnetic pH controlled near 5.8. Some of these species lost during acidification have returned, and some lake trout reproduction has resumed. Other affected species have not yet begun to recover. A further year at pH 5.8 is planned for 1990.

In Lake 302, a double basin acidification study has been underway since 1980. The pH of the south basin, receiving additions of sulphuric acid, was reduced to 4.6 during 1988, and food

chain observations are continuing. As in Lake 223, a number of species have been lost, and some new species have appeared. For the second year, the pH of the north basin was held at approximately 5.5., using hydrochloric acid, to continue the study of effects of lowered pH on the bacterial communities controlling the nitrogen cycle.

A whole lake cadmium experiment continued on Lake 382 during 1988. This involved additions of both radiotracer and "cold" cadmium to delineate ecological pathways and physiological effects. The cadmium concentration averaged approximately 50 ng/L, much less than the current "safe standard" for protection of aquatic organisms. The experiment will continue in 1989 with a target concentration of 120 ng/L.

A wetland acidification experiment, underway since 1983, continued on the Lake 239 bog. Effects on outflow chemistry are being monitored, and the direct effects on flora and insect fauna are under observation.

Background monitoring continued on a small terrestrial watershed in preparation for a possible acidification study. Weirs have been installed to subdivide the watershed and permit closer evaluation of flows and mass balances.

An experiment began in Lake 260 to study the effects of two organic pesticides, toxaphen and chlordane, on survival, growth, and gamete production of lake trout and white suckers. Selected fish were injected with the chemicals, then released in the lake, their natural habitat, pending later recapture and testing. This study, and another study involving dibenzofurans will continue in 1989.

The ELA has also designated five lakes (111, 224, 239, 262, 373) for inclusion in the DFO

LRTAP lake monitoring program, which should continue for 15 to 20 years. Water chemistry and selected biota were monitored in 1988 using standardized methods. Comparisons will be made with lakes in other regions.

Report: Reports and information are available from: Freshwater Institute, Winnipeg, Manitoba.

Pacific Salmon Biomonitoring

Department of Fisheries and Oceans, Pacific Region, Habitat Management Division, is implementing micro-sampling techniques developed in 1987/88 to characterize sublethal stress responses in very young salmon exposed to episodic pH depressions in a stream-fed hatchery facility. Blood and tissue chemistry samples in this cooperative program are analyzed at the DFO Freshwater Institute in Winnipeg.

Simon Fraser University researchers are cooperating with DFO through provision of facility support for concurrent laboratory bioassays (sublethal stress measurement) using Pacific salmon juveniles.

Departmental Technical and Data reports are proposed to present sublethal stress results and an annotated bibliography on the sensitivity of stream invertebrates to acidification.

Report: Information may be obtained from: Habitat Management Division, Pacific Region, Fisheries and Oceans Canada, Vancouver, British Columbia.

7.4 SOILS AND GEOLOGY

Yukon Soils and Geology Sensitivity Mapping

The objective of this project is to produce maps of: (1) the potential of soil and geology to

reduce the acidity of incoming acid deposition affecting the aquatic resource; and (2) soil sensitivity to acid deposition affecting vegetation. The project was completed in 1988, and the data are available as part of the national sensitivity map series.

Report: Information is available from:
Pacific Forestry Center, Forestry
Canada, Victoria, British Columbia.

7.5 VEGETATION

Acid Rain National Early Warning System (ARNEWS)

The Acid Rain National Early Warning System was established to clearly and accurately detect signs of acid rain damage to forests before damage becomes obvious. A nation wide network of permanent plots has been established by Forestry Canada to detect and monitor changes in forest soil, vegetation, and trees.

The objective of the program is to obtain baseline data on the concentrations of foliar and soil elements, foliar and tree condition (including insect and disease levels), and tree growth. The baseline studies are to be followed up by detection and monitoring of possible changes to the baseline conditions over a planned 20 to 25 year period. A national establishment report is in press and the manual on plot establishment and monitoring (Infor. Rept. DPC-X-25) was published in 1988.

Fifteen nationally standardized forest plots have been established as part of the ARNEWS program in British Columbia. Detailed soil and foliar chemical analyses are now available for all 25 British Columbia plots. Baseline data have been obtained. Acid rain injury was not readily observable. Yearly monitoring of vegetation condition is continuing.

Report: Information is available from:
Forestry Canada, in both Victoria,
British Columbia and Edmonton,
Alberta.

Biomonitoring Studies on Selected ARNEWS Plots

Thirty-four subplots were established in five British Columbia ARNEWS sites. Presence, health, and percent cover of terrestrial mosses, lichens, and liverworts were recorded. Six permanent arboreal subplots were established and pollution sensitive lichens transplanted. Initial results showed no visible damage to any of the plants. A reassessment of the lichen transplants was made during 1988 and a report is in preparation. While some lichens died, shading may have been a confounding factor. Others survived, and elemental levels were within the range reported in the literature. Expansion of the biomonitoring system is recommended.

Report: Information is available from:
Pacific Forestry Center, Forestry
Canada, Victoria, British Columbia.

Analysis and Interpretation of Stream and Precipitation Chemistry for the ARNEWS Plot at the UBC Research Forest

Data collected since 1971 at the University of British Columbia (UBC) Research Forest, near Haney, British Columbia, suggest that the soils and vegetation are absorbing most of the incoming hydrogen ions, and significant amounts of hydrogen or aluminum ions are not being leached into the stream. However, increased atmospheric hydrogen ion inputs could stress the system, resulting in the release of these ions. Nitrate and sulphate concentrations in precipitation have increased with time, as has nitrate in the streamwater. No further work was done in 1987 or 1988.

Report: Reports are available from: Pacific Forestry Center, Forestry Canada, Victoria, British Columbia.

Search for Chemical Stress Indicators in Conifers

A preliminary study has been initiated at Alice Arm, British Columbia, to determine the effects of chemical pollutants on conifers by examining tree foliage chemicals. Dr. Manville is looking for stress indicator substances. The amount and effect of deposition of airborne sulphur pollutants from a pulp mill on the foliar chemistry of Douglas-fir and Western hemlock conifers is being investigated, specifically, the foliar terpene composition for the needles of individual trees. Analyses were conducted using techniques developed at PFC for determining the terpene composition of small samples by mixed solvent extraction and dual column chromatographic identification of isolated components. GC-MS and GC-FTIR will be employed to identify new or unanticipated compounds if such are found during the course of this investigation.

Dr. Manville has sampled a number of individual trees. If obvious differences are noted for affected individual trees relative to obviously healthy individuals from the same region, he will plan an intensive sampling program and conduct appropriate analyses to determine at what levels of pollution this approach can airborne pollutant deposition induced stress-cause chemical changes in conifer chemistry.

Report: Information is available from: Pacific Forestry Center, Forestry Canada, Victoria, British Columbia

7.6 HEALTH

Contaminants in Polar Bears

The Canadian Wildlife Service (CWS) has recently completed a comprehensive survey of Chlorinated Hydrocarbon Contaminants (CHC) and heavy metals in Polar Bear throughout their range in the Northwest Territories of Canada. Samples of fat and liver were taken by Inuit hunters in 1982-84 and analyzed to identify and quantitate CHC accumulating in the bears. A wide range of CHC was identified, some not previously reported in the Arctic. The most significant finding was the pesticide, technical chlordane. The types of CHC were the same in all areas, in spite of a wide difference in origins of the tissue. Levels were generally inversely correlated to latitude, as expected for mid-latitude sources and relative isolation of the Arctic air mass. The patterns in contamination were similar in most respects to North Atlantic air 5 to 8 years before. CHC are clearly being transported to the Arctic from mid-latitudes by air currents. Relatively high levels of PCB's, and the pesticide metabolite oxychlordane, were present along with lesser amounts of DDE, dieldrin, HCB, and alpha-HCH. Distribution of the more water-soluble alpha-HCH was affected by runoff from land. A study on the accumulation of CHC in the Arctic Cod/Ringed Seal/Polar Bear - food chain has also been carried out.

Re-analysis of Polar Bear fat samples from the CWS specimen bank showed that the level of most CHC, especially chlordane compounds, had increased in the 1969-1982/84 time period in Hudson Bay and Baffin Bay bears. To establish whether this increase is an anomaly or a long-term trend, a three year international project has been initiated in 1989 to determine the circumpolar and geographical distribu-

tion of CHC in the Polar Bear; and to determine the trend of CHC in Polar Bears in the Canadian Arctic.

Report: Information is available from:
Wildlife Research Center, Canadian
Wildlife Service, Environment
Canada, Ottawa, Ontario.

8. JOINTLY MANAGED ACTIVITIES

8.1 EMISSIONS AND CONTROL TECHNOLOGY

Inventory of Air Pollution in British Columbia

Point Sources Under Waste Management Permit

A summary report on emissions for 1985 for all permitted sources in British Columbia, including those within the Greater Vancouver Regional District, is being printed and will be available in the near future. The contaminants considered in these reports are particulates, sulphur dioxide, nitrogen oxides, carbon monoxide and hydrocarbons.

Report: Information is available from the Ministry of Environment, Waste Management Branch, Victoria, British Columbia.

Area and Mobile Sources Emissions

Environment Canada completed the 1985 emission inventory for those sources in British Columbia. The Ministry of Environment intends to use new Provincial emission inventory databases for Area and Mobile sources, provided by Environment Canada, for future inventories.

Inventory of Air Emissions in Greater Vancouver Regional District

The Greater Vancouver Regional District has analyzed the 1985 emission inventory data and published several reports on emissions from Point, Area and Mobile Sources in its jurisdiction.

This inventory database is also used for other

purposes, such as permit administration, data transfer and dispersion modelling, and will be updated routinely.

Report: Information is available from the Greater Vancouver Regional District, Pollution Control Dept. Burnaby, British Columbia.

Inventory of Volatile Organic Compounds (VOC) from Fuel Marketing in Greater Vancouver Regional District

The second phase of the study commissioned by Environment Canada, in cooperation with the Greater Vancouver Regional District, the Ministry of Environment, and the petroleum industry, is completed, and a report is published.

Report: The information is available from Environment Canada, West Vancouver, British Columbia.

Control Technology Options and Costs For Volatile Organic Compound Emissions From Gasoline Marketing

The Ministry of Environment and Environment Canada, in cooperation with the Greater Vancouver Regional District, Ministry of Energy, Mines and Petroleum Resources and the petroleum industry, retained a consultant to carry out this study. The study investigates the control technology options and costs for reduction of volatile organic compound emissions from the gasoline marketing sector in the Greater Vancouver area. It also addresses the potential impacts of the reduction of gasoline vapour pressure on the emissions in the area.

Report: The information is available in the near future from the Ministry of Environment, Waste Management Branch, Victoria, British Columbia; and Environment Canada, West Vancouver, British Columbia.

Volatile Organic Compound Emissions from Gasoline Marketing; Modelling

As part of the Lower Mainland inventory of emissions of ozone precursor pollutants, Environment Canada and the Greater Vancouver Regional District have completed a software based program containing point, line and area source VOC emissions for gasoline marketing operations. The emissions are speciated according to gasoline vapour compositions, and are resolved into 5 x 5 kilometre grids.

Report: Information is available from: Environmental Protection, Environment Canada, West Vancouver, British Columbia and Greater Vancouver Regional District, Pollution Control Department, Burnaby, British Columbia.

Volatile Organic Compound Emissions from Gasoline Marketing; Reduction of Volatility

A joint project was initiated in 1988 between the B.C. Ministry of Environment and Environment Canada, to assess control technology and costs for reducing VOC emissions at various stages in the gasoline transfer operations from petroleum refineries to vehicle refueling. The study also includes an examination of the benefits of VOC emission reductions if the volatility of motor gasoline is reduced. The Petroleum Association for the Conservation of the Canadian Environment is augmenting the fuel volatility study by examining the technical feasibility and cost implications of producing lower volatility motor gasoline in selected regions of Canada.

Report: Information is available from: Environment Canada, West Vancouver, British Columbia and Greater Vancouver Regional District, Pollution Control Department, Burnaby, British Columbia.

8.2 AIR QUALITY AND DEPOSITION

The Role of Dust in Precipitation Chemistry

The Atmospheric Environment Service, Environment Canada, participates on the Task Group which is pursuing the question of dust and its impact on the precipitation chemistry in western Canada.

Early in 1988, AES sponsored and hosted a workshop to bring together experts on the role of dust in precipitation, and its measurement and analysis.

A consultant's report has been produced, and is expected to be reviewed and published in 1989.

Report: Information is available from: Alberta Environment, Edmonton, Alberta and Atmospheric Environment Service, Edmonton, Alberta.

Chemistry of High Elevation Fog

The province of British Columbia is studying the chemical composition of fog in order to understand the potential impact of atmospheric pollutants on high-altitude ecosystems in south-western parts of the province.

The pilot study of fog chemistry is now under way in North Vancouver. Samples are being collected at two high-elevation sites in Mount Seymour Park. At the 790 metres level, a

passive string collector is used and at the 1000 metres level, collocated passive and active string collectors are used to collect samples.

Pacific Region of the Atmospheric Environment Service is supporting this project by providing the synoptic analysis and meteorological support coincident with the sampling. This is the continuation of a study begun in 1987.

Report: Information is available from Pacific Region, Atmospheric Environment Services, Vancouver, British Columbia and British Columbia Ministry of Environment, Victoria, British Columbia.

8.3 SURFACE WATERS

No activities in this area

8.4 SOIL AND GEOLOGY

No activities in this area

8.5 VEGETATION

No activities in this area

8.6 HEALTH

No activities in this area

9. INDUSTRY AND INSTITUTION ACTIVITIES

9.1 BRITISH COLUMBIA

Greater Vancouver Regional District Air Management Plan

The GVRD is developing a comprehensive air quality management plan to describe present and future air quality issues, and control options to ensure good air quality in the future. The first stage of the plan is to be completed by June 1989; future emissions and air quality will be calculated, based on a detailed inventory of 1985 air emissions projected beyond the year 2000. Stage 2 of the plan will describe options for the control of current and future air quality problems. Among these, transportation planning is likely to be important in influencing future air quality, since approximately 80% of the emissions in the region are from mobile sources.

Report: Information is available from:
Greater Vancouver Regional
District, Pollution Control
Department, Burnaby,
British Columbia.

9.2 ALBERTA

Alberta Government/Industry Acid Deposition Research Program

The Alberta Government/Industry Acid Deposition Research Program (ADRP) is a multi-million dollar program beginning its sixth year in 1988. The program is funded by the Alberta Government, the Canadian Petroleum Association, the Energy Resources Conservation Board, and Alberta's electric utilities. The overall program objectives are as follows:

1. To provide a comprehensive

understanding of the effects and consequences of acid-forming gases on the environment;

2. To provide a scientific basis for sound long-term environmental management and regulatory control with respect to acid-forming gases;
3. To disseminate such information to the Members Committee of the ADRP, to the public and government bodies;
4. To undertake any research deemed appropriate; and
5. To encourage and include opportunities for public represented in the ADRP.

Current work is the \$5.3 million, 42-month Biophysical Research Program to Critical Point I of the ADRP. This work was completed in July 1988. The objectives of the Biophysical Research Program are:

1. To determine if at present, there are observed or measurable regional scale adverse effects of acidic or acidifying pollutants on Alberta's crops, soil, and surface waters.
2. If the answer of objective (1) is negative, then determine when, where, and under what circumstances will such adverse effects occur in Alberta.

All of the results and conclusions of the Biophysical Research Program to Critical Point I were released to the public in September 1988.

Overall, regional scale impacts of acidic deposition on crops, soils, and surface waters were not demonstrated and likely absent with the reservation of possible small impacts on alfalfa growth in a few areas. Large increases in acidic deposition could impact certain crops, forest trees, soils, and surface waters in a few

sensitive areas of Alberta.

Incursions of high ozone concentrations into Alberta were detected at the Fortress Mountain background air quality monitoring station. There were 254 occasions in 1987 when the hourly average ozone concentration exceeded the 80 ppb air quality objective. Long-range transport of pollutants from urban centres in British Columbia and the State of Washington is suggested. It is recommended that the Fortress Mountain air quality monitoring station be reinstated.

The results and conclusions of the multi-disciplinary Biophysical Research Program were reviewed and evaluated by an internationally recognized team of scientists which formed the Science Advisory Board (SAB). They rated the research as one of the most comprehensive studies of air pollution in the world. The Public Advisory Board (PAB) concurred with the SAB.

The conclusions of the Biophysical Research Program to Critical Point I, along with the Recommendations of the SAB and PAB, are currently under review by the Members Committee of the ADRP. The results of this review are expected in early 1989.

Report: All published reports are available from the office of the Acid Deposition Research Program. Microfiche or paper copies are also available through Micromedia Ltd., 158 Pearl Street, Toronto, Ontario M5H 1L3.

9.3 SASKATCHEWAN

Saskatchewan Power Corporation Monitoring Activities at Poplar River (Coronach) and Boundary Dam (Estevan) Power Stations

One station continuously monitoring ground

level concentrations of sulphur dioxide is located at the Canada/U.S. International Boundary south of the Poplar River Power Station. Emissions at the Poplar River Power Station are continuously monitored for opacity, sulphur dioxide, and nitrogen oxides concentrations. Surface waters in the vicinity of the Poplar River, Boundary Dam, Queen Elizabeth, and Estevan power stations are monitored and analyzed for pH, sulphates, nitrates, alkalinity, etcetera.

Report: Further information is available from the Saskatchewan Power Corporation and Saskatchewan Environment and Public Safety.

Saskatchewan Power Corporation Agricultural Monitoring Program - Poplar River Power Plant, 1988

As part of this program, the Saskatchewan Research Council measured sulphation levels at eighteen sites. Rainfall samples at three sites were collected and analyzed for pH, sulphate, nitrate, calcium, magnesium, potassium, sodium, chloride and specific conductance. Soil chemistry was monitored for pH and sulphur content and wheat crops were analyzed for chlorophyll-a, chlorophyll-b, nitrogen and sulphur.

Report: Further information is available from the Saskatchewan Power Corporation.

Saskatchewan Power Corporation - SO₂ Emission Reduction

Preliminary investigations were conducted into adding a humidification stage to the in-furnace injection of calcium-based sorbents. This review indicated the potential for increased SO₂ reduction using limestone as the sorbent material.

Funding is being sought by Sask Power and Tampella Limited, a Finnish boiler manufacturer, for a joint project to install a demonstration humidification system (LIFAC). Samples of Saskatchewan lignite were sent to Finland for pilot scale tests at the Tampella LIFAC test facility.

Report: Information available from the Director, Materials Research, Research and Development Centre, Saskatchewan Power Corporation.

Saskatchewan Power Corporation - Development of Improved Reagents for SO₂ Capture in Dry Injection Systems

Laboratory tests and experimentation are continuing on development of improved calcium-based reagents for abatement of sulphur dioxide emissions. Potentially cost-effective methods of achieving finer calcium hydroxide sorbents have been identified in the work done previous to this year. Whether these improvements in sorbent particulate size translate into greater reactivity to SO₂ will be determined in work planned for next year, including completion of a bench scale reactor, designed to simulate furnace conditions expected at the hand plant presently being built.

Report: Information available from Director, Materials Research, Research and Development Centre, Saskatchewan Power Corporation.

Saskatchewan Power Corporation Disposal Procedures of Ashes Recovered From Power Plants Where Dry Sorbent Injection Has been Used to Control SO₂ Emissions

Synthetic ashes consisting of power plant fly ash and additions of lime and calcium sulphate have been prepared to simulate ashes expected from a future power plant where dry sorbent

injection technology will be used to control SO₂ emissions. These ashes have been studied for leaching characteristics, heat evolution upon water contact, permeability, swelling and setting. The clays surrounding the ash disposal site have been studied for their capacity to retain ash leachate. In addition, preliminary studies have been carried out on the setting and permeability properties of these ashes when mixed with Bentonite. Utilization options for these ashes are also being examined.

Report: Information available from Director, Materials Research, Research and Development Centre, Saskatchewan Power Corporation.

Saskatchewan Power Corporation - Environmental Studies

Methods are researched for identification and monitoring of toxic emissions from power plants. Special techniques and a QA program were developed for identification and analysis of PCB compounds. No reports are available.

Report: Information available from Director, Materials Research, Research and Development Centre, Saskatchewan Power Corporation.

Saskatchewan Power Corporation Lignite Coke for SO₂ Abatement

Lab scale coking studies utilizing Saskatchewan lignite have produced cokes with high surface areas. Initial tests have shown that gases with up to 1000 ppm SO₂ can be completely desulphurized by passing through a bed of this coke. Tests are underway to determine the sulphur removing capacity of these cokes.

Report: Information available from Director, Materials Research,

Research and Development Centre,
Saskatchewan Power Corporation.

Monitoring at AMOK Ltd. Uranium Mine, Cluff Lake

The average sulphation levels are determined on a monthly basis at 23 sites around the mine using lead peroxide plates.

Report: Data summaries are available from Amok Ltd. and Saskatchewan Environment and Public Safety.

Monitoring at Eldor Mines Uranium Mine, Rabbit Lake

Eldor Mines continuously monitors ground level concentrations of sulphur dioxide at one site.

Report: Data summaries are available from Eldor Mines and Saskatchewan Environment.

Comparative Injury to Saskatchewan Vegetation Caused by Acidic Precipitation

The objectives of this research are: (1) To compare the sensitivities of plant tissues to acidification, primarily by use of the membrane leakage test, and (2) To investigate the mode of injury from excess acidity, including the direct effects of hydrogen ions, and the synergistic effects of other ions. Comparisons are being made on several important boreal species, including trees, shrubs and herbs. The study will be completed in 1989.

Report: Further information is available from R.E. Redmann, Department of Crop Science and Plant Ecology, University of Saskatchewan.

9.4 MANITOBA

Damage to Plant as a Result of Environmental Stresses

Damage to plants as a consequence of environmental stresses, physical and chemical are being investigated by the Botany Department of the University of Brandon. Decline in shelterbelt trees and natural bush in south-west Manitoba has been noticed. There is no evidence of soil acidification because the soils are well-buffered and pH values in the affected areas ranges from 6.5 to 7.8. However, reviews of the scientific literature on tree decline in parts of Europe does not rule out an influence of pH at the plant leaf/stem level in the Manitoba decline. Samples of rain are being collected from different locations in Brandon and rural Manitoba to verify this theory. The study is an ongoing project.

Report: Further information is available from the University of Brandon, Brandon, Manitoba.

Monitoring in Flin Flon

One station continuously monitors ground level concentrations of sulfur dioxide within 5.0 kilometres (km) of the 250 metre high main stack of the non-ferrous smelter facility. The station is operated by Hudson Bay Mining and Smelting. In December an additional station was put in place by Manitoba Environment.

Report: Data summaries are available through Hudson Bay Mining and Smelting Company Ltd.

Removal of Sulfur - Hudson Bay Mining and Smelting

Studies to research and develop process tech-

nology have been done, or are currently underway, to reduce emissions from the zinc and copper producing operations of Hudson Bay Mining and Smelting Company at Flin Flon. Incorporation of these process changes is pending financing.

Report: These are ongoing programs. Further information is available through Hudson Bay Mining and Smelting Company Ltd.

Monitoring in Thompson

A permanent station continuously monitoring ground level concentrations of sulphur dioxide is northwest of the Inco non-ferrous smelter facility located between the plant and the Town of Thompson. A mobile station is used during the spring, summer, and early fall (during the growing season) to monitor sulphur dioxide concentrations from other directions. A telemetry system has recently been installed which improves the ability to obtain data.

In addition to measuring ground level concentrations of sulphur dioxide, there is a meteorological program to regulate the smelter

production so that acceptable concentrations of sulphur dioxide are maintained under differing dispersion conditions.

Satellite imagery is being used to detect and map vegetation changes in the Thompson area. Maps have been prepared for 1973, 1978 and 1983.

Report: Data summaries are available from Inco Limited.

Removal of Sulphur - Inco

A research program is being conducted by Inco Ltd., Manitoba Division, on the reduction of sulphur in the concentrate being smelted. The program, which is sponsored under the Canada/Manitoba Mineral Resources Development Agreement, is investigating techniques for increased economical removal of high sulphur pyrrhotite in the mill with minimization of metal losses in the smelting process.

Report: This is an ongoing program. Further information is available through Inco Limited.

10. ADDRESSES FOR FURTHER INFORMATION

BRITISH COLUMBIA

Ministry of Environment and Parks
Parliament Buildings
Victoria, British Columbia
V8V 1X5

ESSA Environmental and Social
Systems Analysts
#705 - 808 Nelson Street
Vancouver, British Columbia
V6Z 2H2

Institute of Animal Resource Ecology
2204 Main Mall
University of British Columbia
Vancouver, British Columbia
V6T 1W5

Greater Vancouver Regional District
Pollution Control Department
4330 Kingsway
Burnaby, British Columbia
V5H 4G8

ALBERTA

Acid Deposition Research Program
3810, 150 Sixth Avenue S.W.
Calgary, Alberta
T2P 2Y7

Alberta Environment
Environmental Assessment Division
6th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

Alberta Environment
Corporate and Strategic
Management Division
Main Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

Alberta Environment
Soil Protection Branch
Waste and Chemicals Division
P.O. Box 3014
Cousins Building
Lethbridge, Alberta
T1J 4B3

Alberta Environmental Centre
Bag 4000
Vegreville, Alberta
T0B 4L0

MANITOBA

Director Environmental Control
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Supervisor,
Safety, Health and Environment
Inco Ltd.
Manitoba Division
Thompson, Manitoba
R8N 1P3

Manitoba Environment
Environmental Standards & Studies
Box 7, Building 2
139 Tuxedo Avenue
Winnipeg, Manitoba
R3N 0H6

Brandon University
Botany Department
Brandon, Manitoba
R7A 6A9

NORTHWEST TERRITORIES

Pollution Control Division
Renewable Resources
Government of the Northwest Territories
P.O. Box 1320
Yellowknife, Northwest Territories
X1A 2L9

Wildlife Service
Renewable Resources
Government of the Northwest Territories
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SASKATCHEWAN

Amok Ltd.
817, 825 - 45th Street West
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Department of Crop Science and
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University of Saskatchewan
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Eldor Mines
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Saskatchewan Environment and
Public Safety
Walter Scott Building
3085 Albert Street
Regina, Saskatchewan
S4S 0B1

Institute of Pedology
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0

Saskatchewan Power Corporation
2025 Victoria Avenue
Regina, Saskatchewan
S4P 0S1

Saskatchewan Research Council
15 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 2X8

FEDERAL AGENCIES

ALBERTA (FEDERAL)

Canadian Wildlife Service
Environment Canada
2nd Floor
4999 - 98th Avenue
Edmonton, Alberta
T6B 2X3

Environmental Protection
Western and Northern Region
Conservation and Protection
Environment Canada
3rd Floor, Twin Atria #2
4999 - 98th Avenue
Edmonton, Alberta
T6B 2X3

Northern Forestry Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Scientific Services Division
Western Region
Atmospheric Environment Service
2nd Floor, Twin Atria Building
4999 - 98th Avenue
Edmonton, Alberta
T6B 2X3

BRITISH COLUMBIA (FEDERAL)

Environmental Protection
Pacific and Yukon Region
Conservation and Protection
Environment Canada
3rd Floor, Kapilano 100
Park Royal
West Vancouver, British Columbia
V7T 1A2

Fisheries and Oceans Canada
Fisheries - Pacific Region
1090 West Pender Street
Vancouver, British Columbia
V6E 2M9

Scientific Service Division
Pacific Region
Atmospheric Environment Service
700 - 1200 West 73rd Avenue
Vancouver, British Columbia
V6P 6H9

Institute of Ocean Sciences
9860 West Saanich Road
Box 6000
Sidney, British Columbia
V8L 4B2

Pacific Forestry Centre
Canadian Forestry Service
506 West Burnside Road
Victoria, British Columbia
V8Z 1M5

MANITOBA (FEDERAL)

Freshwater Institute
Department of Fisheries and Oceans
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Scientific Services Division
Central Region
Atmospheric Environment Service
266 Graham Avenue
10th Floor, Room 1000
Winnipeg, Manitoba
R3C 3V4

NORTHWEST TERRITORIES (FEDERAL)

Inland Waters/Lands
Environment Canada
Box 2970
Yellowknife, NWT
X1A 2R2

ONTARIO (FEDERAL)

Atmospheric Research Directorate
Atmospheric Environment Service
4950 Dufferin Street
Downsview, Ontario
M3H 5T4

Health and Welfare Canada
Brooke Claxton Building
Ottawa, Ontario
K1A 0K9

LRTAP Liaison Office
4950 Dufferin Street
Downsview, Ontario
M3H 5T4

SASKATCHEWAN (FEDERAL)

Inland Waters/Land
Western and Northern Region
Conservation and Protection
1st Floor, Motherwell Building
1901 Victoria Avenue
Regina, Saskatchewan
S4P 3R4

Scientific Services Division
Central Region
Atmospheric Environment Service
Airport Terminal Building
Box 4800
Regina, Saskatchewan
S4P 3Y4

11. GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ADRP	- Acid Deposition Research Programme (Alberta)	kg/ha/yr	- Kilograms per hectare per year
AES	- Atmospheric Environment Service	LRTAP	- Long Range Transport of Air Pollutants
ARNEWS	- Acid Rain National Early Warning System	PCB	- Polychlorinated Biphenyls
CANSAP	- Canadian Network for Sampling Precipitation	PNWIS-APCA	- Pacific Northwest International Section - Air Pollution Control Association
CAPMoN	- Canadian Air and Precipitation Monitoring Network	QA	-Quality Assurance
EPA	- Environmental Protection Agency (U.S.)	RMCC	- Research and Monitoring Co-ordinating Committee
EPRI	- Electric Power Research Institute	SO ₂	- Sulphur dioxide
		NO _x	- Nitrous oxides
		ZAPS	- Zonal Air Pollution System